SPECTRUM SENSING METHODS

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CReATION - Cognitive Radio Transceiver Design for Energy Efficient Data Transmission

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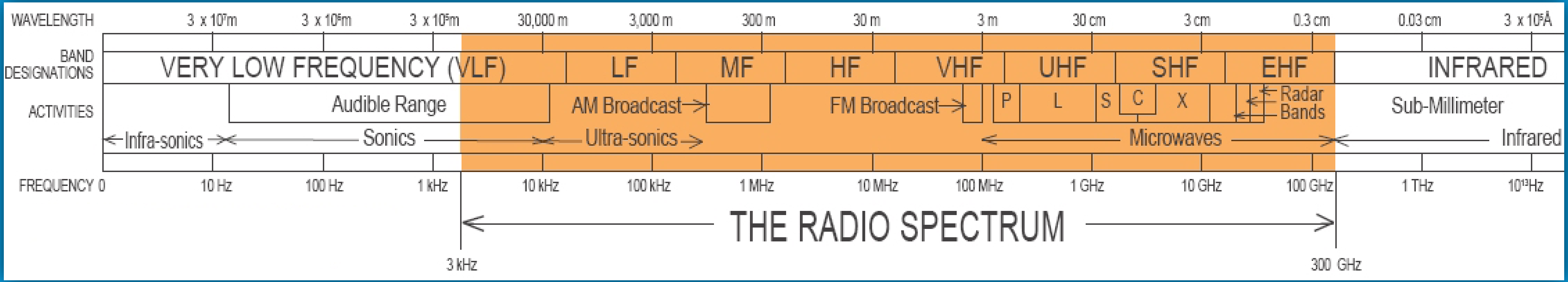
CONTENTS

INTRODUCTION

- The concept behind Cognitive Radio is to exploit underutilized spectral resources by reusing unused spectrum in an opportunistic manner

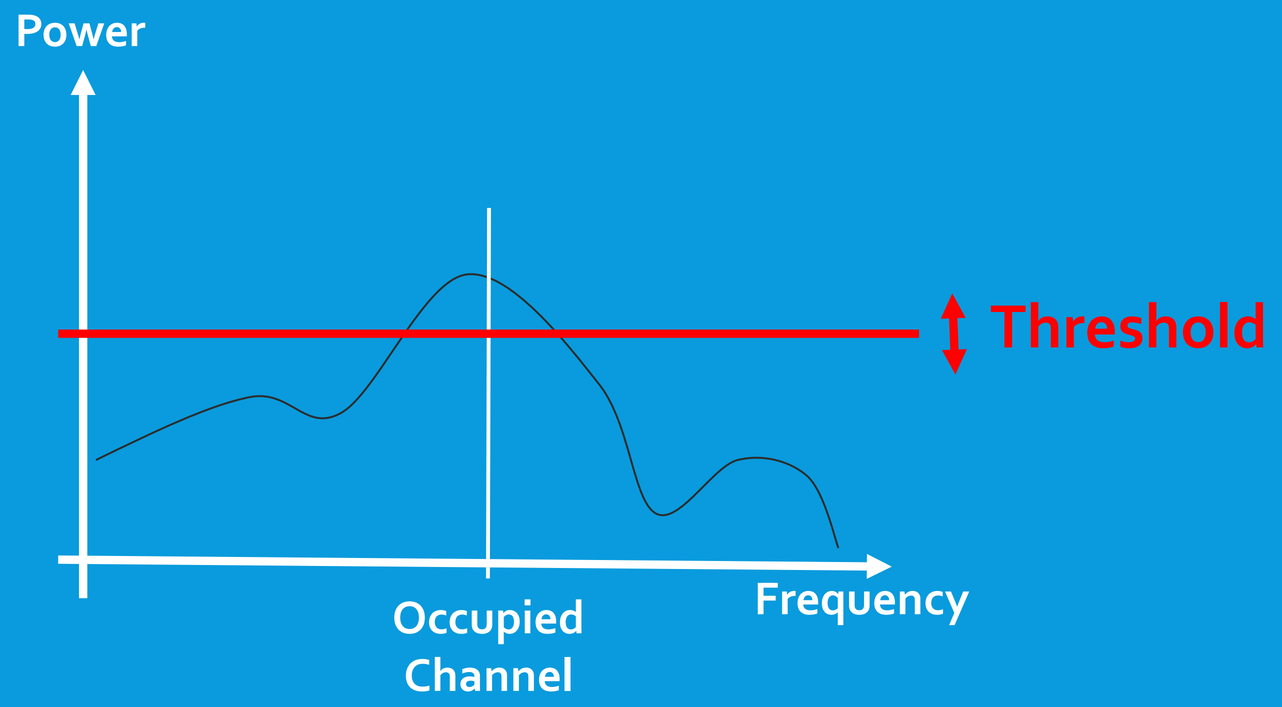


- But how can we effectively detect what spectrum band is not being used at a certain time?

Spectrum Sensing

SPECTRUM SENSING BASICS

- The most used method of detecting the usage of a frequency band is the **Energy Detection Method**



CYCLOSTATIONARITY

- A signal shows cyclostationairty if:
  - Auto-correlation function is periodic with time
  - The mean also shows periodicity
- What signals are cyclostationary:
  - Signals that use a finite constellation to represent digital data will eventually lead to the same symbol being repeated that will create a periodic auto-correlation

↓

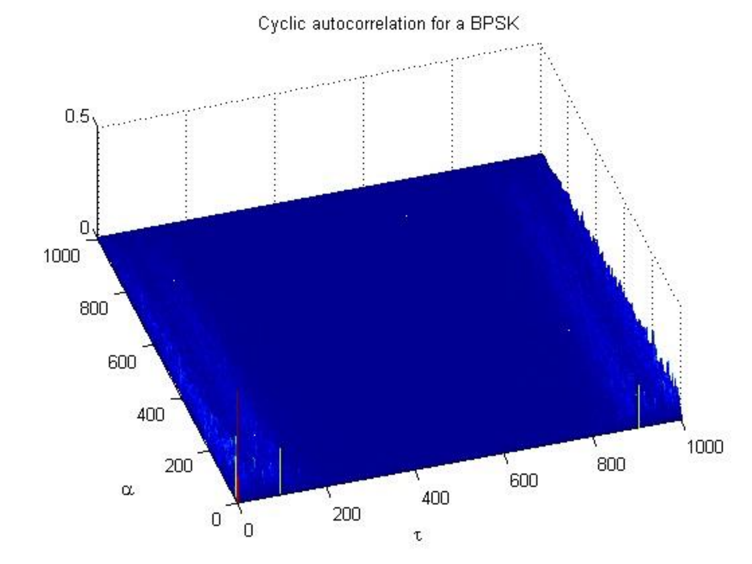
All digital modulations signals that use a finite constellation show a certain degree cyclostationary

CYCLIC AUTOCORRELATION

- Auto-correlation: $R_x(t,\tau) \triangleq E\{x(t+\tau)x^*(t)\}_t$
- Cyclic auto-correlation: $R_x^\alpha(\tau) \triangleq E\left\{x(t+\tau)x^*(t) * e^{-j2\alpha t}\right\}_t$

For a sinusoide exemple:

$$R_x^\alpha(\tau) = \frac{1}{4}\delta(\alpha + 2w_0)e^{-jw\tau} + \frac{1}{4}\delta(\alpha - 2w_0)e^{jw\tau} + \frac{1}{2}\delta(\alpha)\cos(w_0\tau)$$



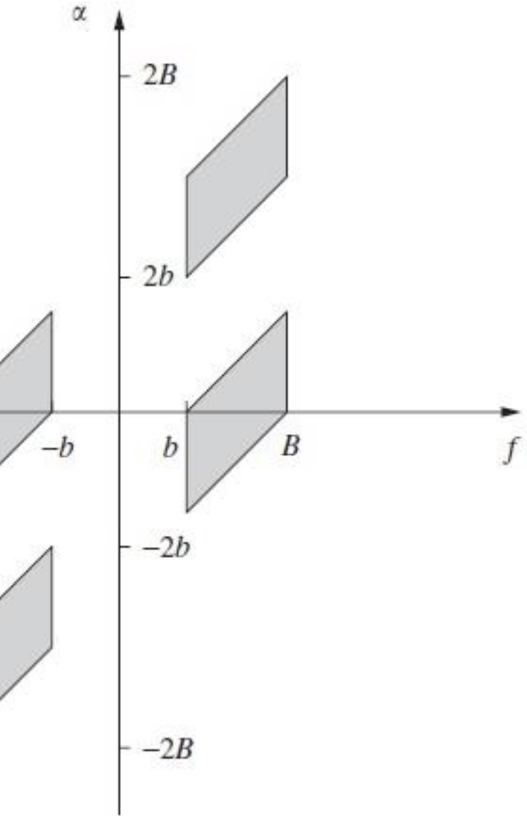
Nº of samples = 1000

$F_c = 0{,}05\mathrm{F_S}$

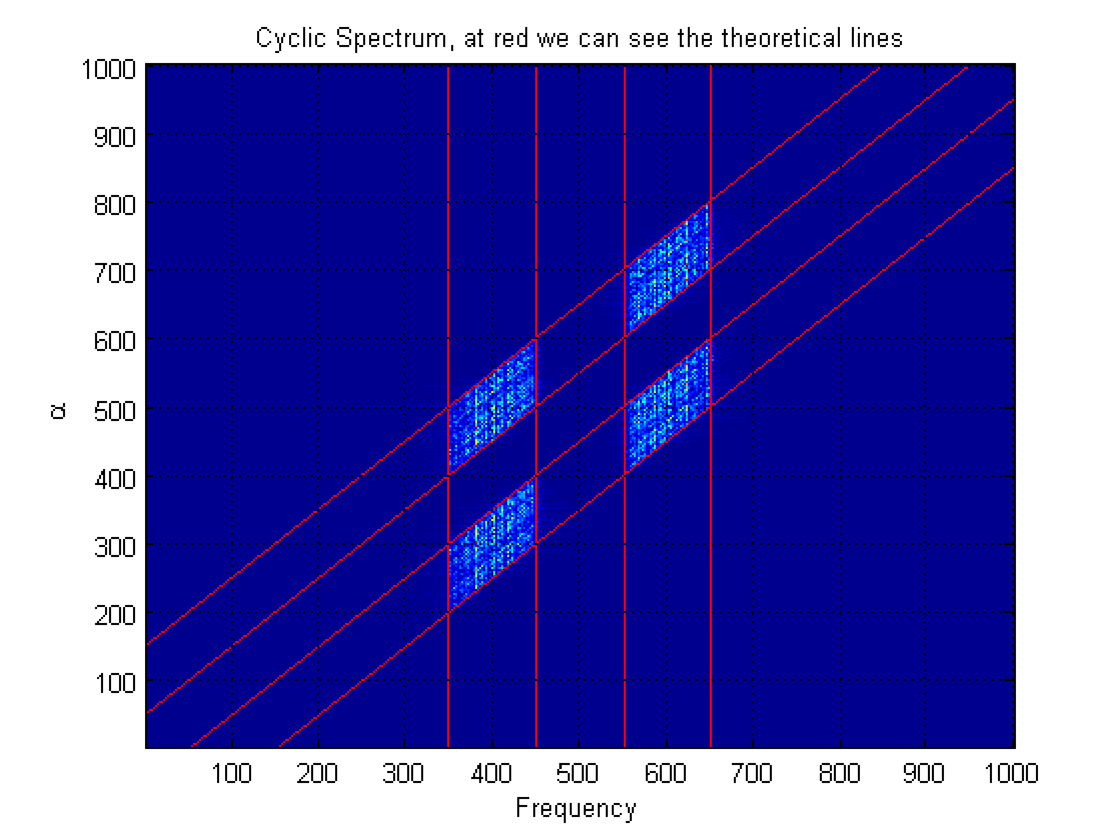
CYCLIC SPECTRUM

- $S_x^{\alpha} = \int R_x^{\alpha}(t) * e^{-j2\pi f\tau} d\tau$, f $= \pm\, \alpha/2$

b = Lower cut frequency
B = Upper cut frequency



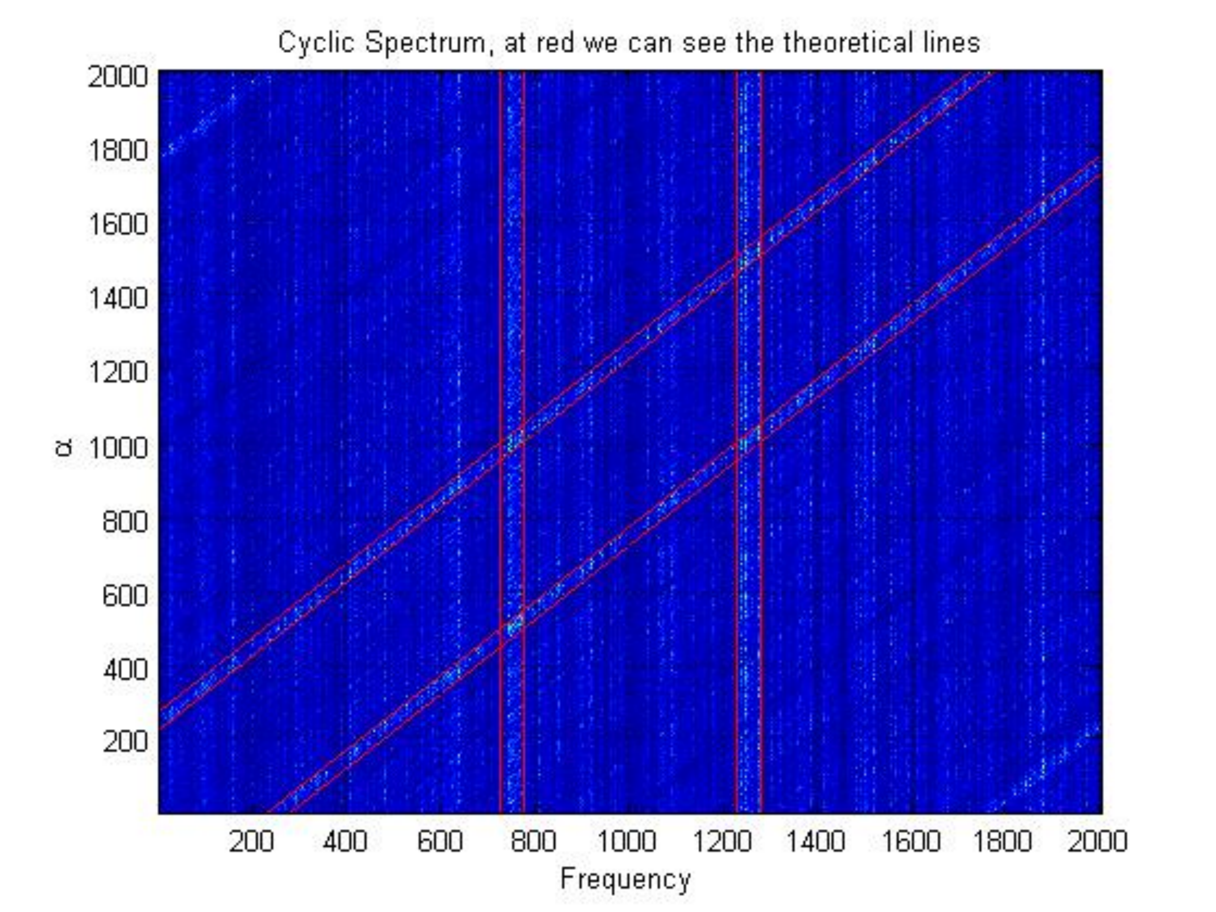
Test for Band Pass of White Noise



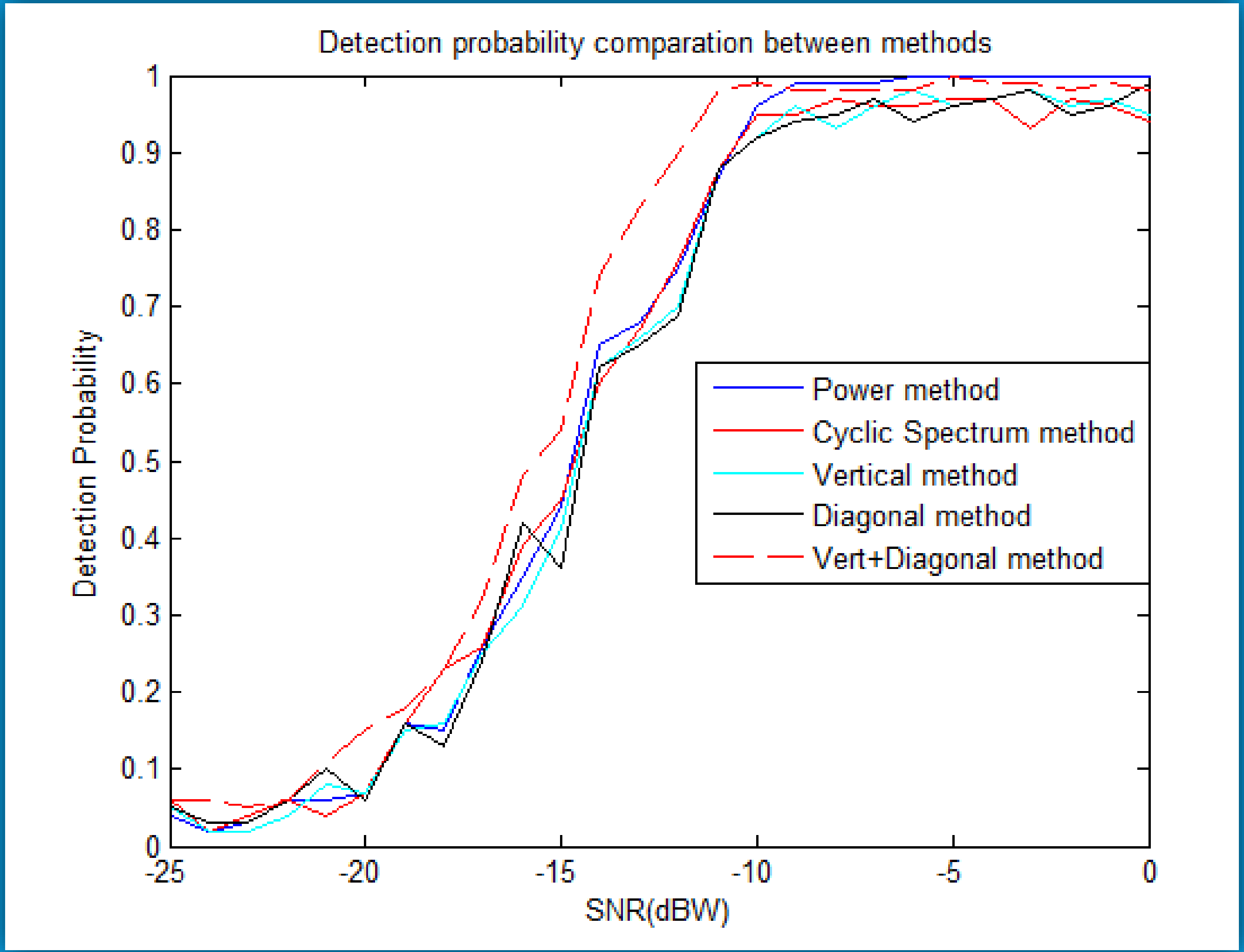
Nº Samples = 1000
$F_C = 0{,}2F_S$
$BW = 0{,}2F_S$

CYCLIC SPECTRUM

Cyclic Spectrum leakage under high noise



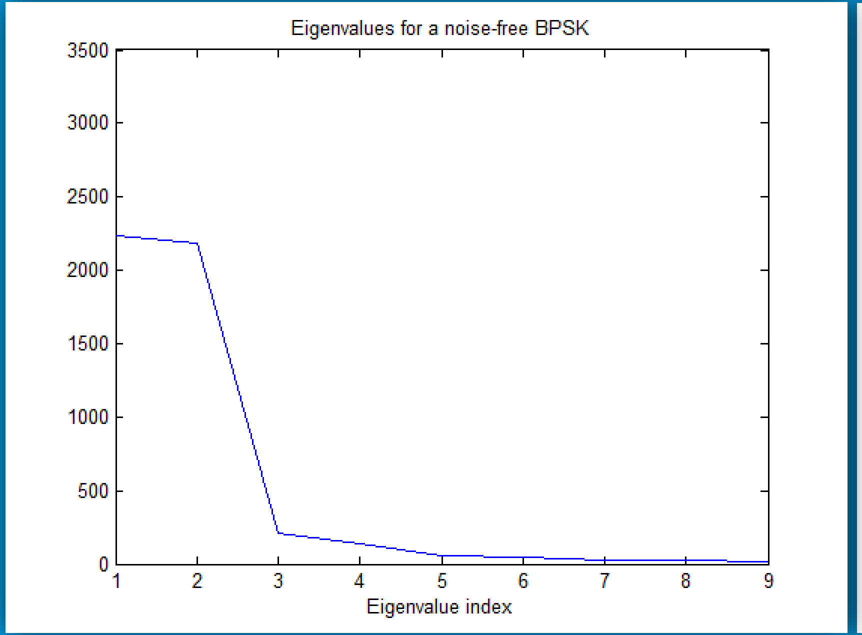
CYCLIC SPECTRUM

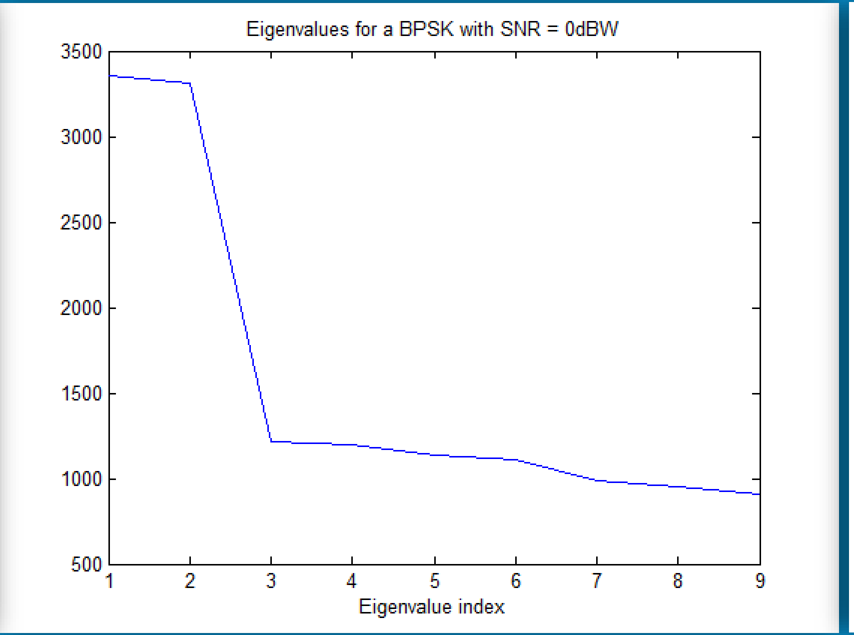


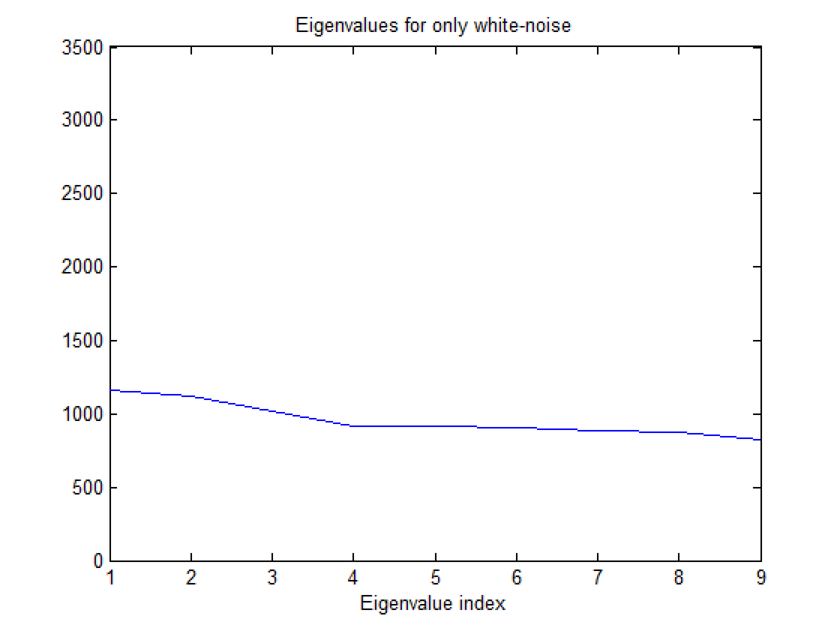
- Blind test with no previous knowledge
- Probability of finding where the signal is in the spectrum
- $F_C = 0{,}1 F_S$
- $BW = 0{,}1 F_S$
- Modulation = BPSK
- Nº Samples = 1000
- Nº tests = 100

EIGENVALUE-BASED SPECTRUM SENSING

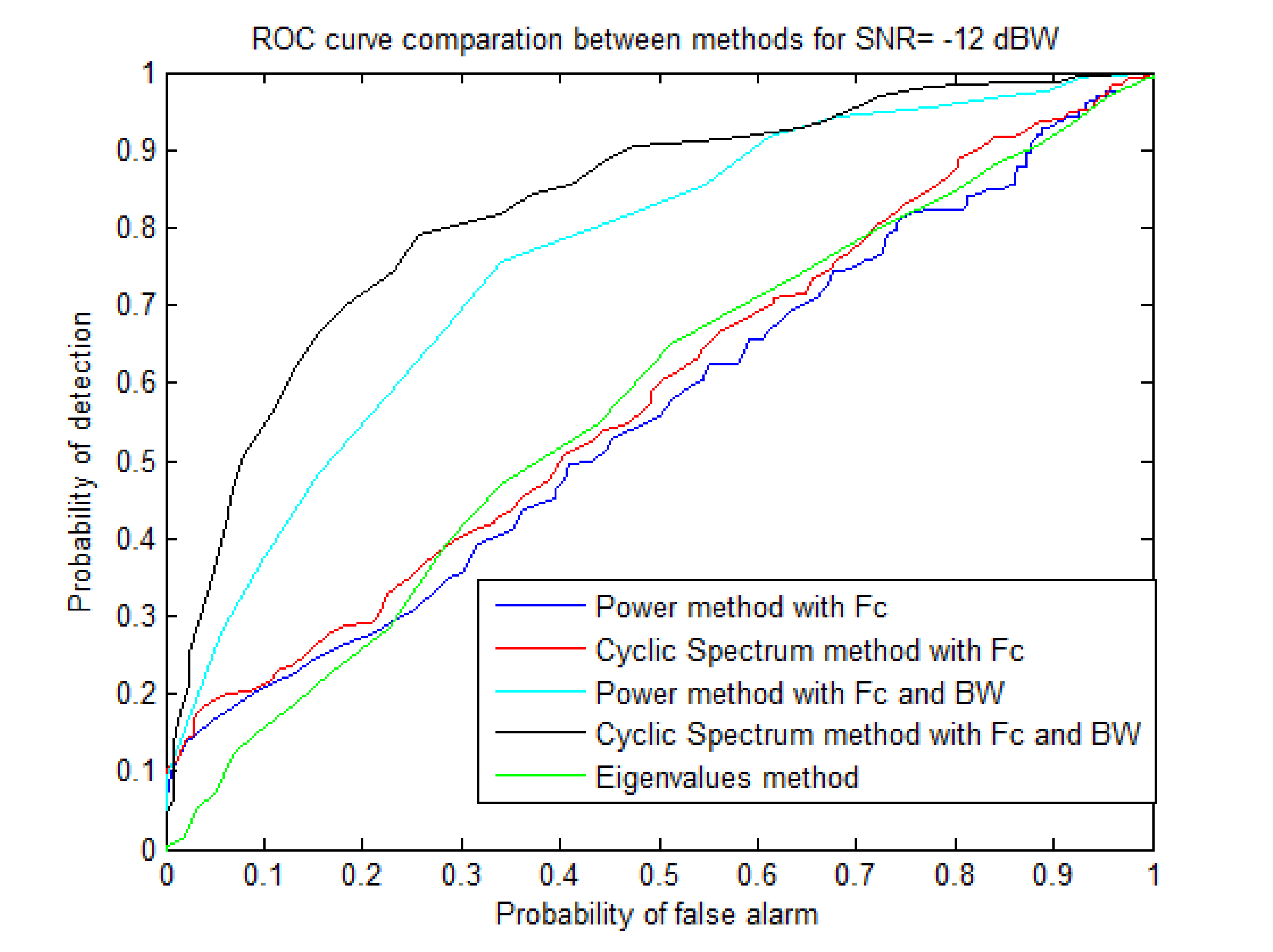
- $\boldsymbol{y}(n) = [x(n), x(n+1), x(n+2), \ldots x(n+M)]^T$, x(n) being the received signal
- Covariance matrix: $R \triangleq \frac{1}{N}\sum_{n=1}^{N} \boldsymbol{y}[n] * \boldsymbol{y}[n]^H$, N = length(x) - M
- Then use the eigenvalues of R trough a threshold to detect if we have signal







METHODS COMPARISON



- $F_C = 0{,}2F_S$
- $BW = 0{,}04F_S$
- Modulation = BPSK
- Nº Samples = 500
- Nº tests = 500
  - Half with signal and half without signal
- Nº of thresholds = 250

CONCLUSIONS

- Cyclostationarity analysis doesn't show visible better results *per se* against energy detection in a blind detection test
- Cyclic Spectrum analysis show better results if we take in advantage the use of the vertical and diagonal leakage
- Cyclostationary methods shows better results than energy detection methods if we have previous knowledge of some signal properties
- Eigenvalue-based spectrum sensing needs more testing to conclude if it's better or not than energy detection

QUESTIONS?